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THE HORN FLY.

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U. S. DEPARTMENT OF AGRICULTURE.

SPECIAL BULLETIN.

DIVISION OF ENTOMOLOGY.

THE
HORN FLY

(HEMATOBIA SERRATA),

BEING AN ACCOUNT OF ITS LIFE-HISTORY AND THE MEANS
TO BE USED AGAINST IT.

BY

C. V. RILEY AND L. O. HOWARD.

[Reprinted from Insect Life, Vol. II, No. 4, October, 1889, by authority of
the Secretary of Agriculture.]

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1889.

NOTICE TO CATTLE OWNERS.

Inasmuch as this bulletin will be sent almost exclusively to persons interested in cattle raising, we desire to take this opportunity of asking such individuals to keep a lookout for this fly, and upon its appearance in their vicinity to notify the Division of Entomology. If, as our present information tends to show, this insect is an imported pest, its spread will probably continue, and it is very desirable that we be informed of every step in its progress. Information as to the trial of remedies and preventives, and individual experience as to results, are also especially requested.

C. V. RILEY,

Entomologist.

U. S. DEPARTMENT OF AGRICULTURE.

SPECIAL BULLETIN.

DIVISION OF ENTOMOLOGY.

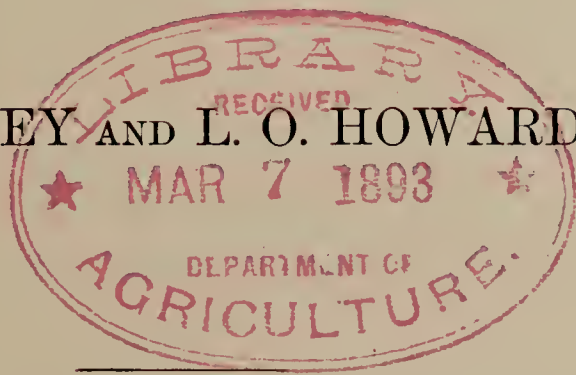
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THE HORN FLY.

(*Hæmatobia serrata* Robineau-Desvoidy.)

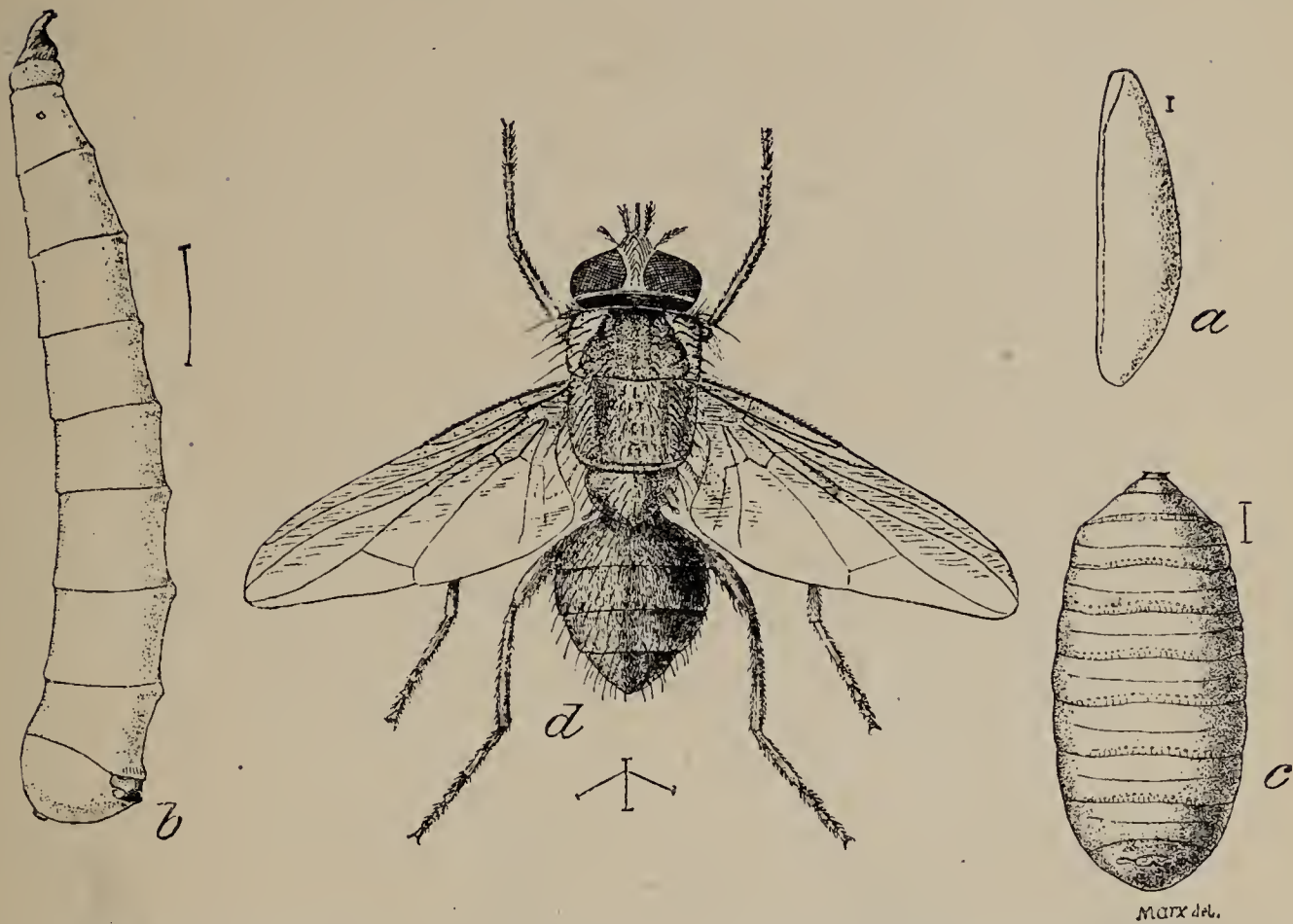


FIG. 11.—HÆMATOBIA SERRATA: *a*, egg; *b*, larva; *c*, puparium; *d*, adult in biting position—all enlarged. (Original.)

Our knowledge of this pest is now sufficiently far advanced to enable us to present a preliminary article giving the main facts ascertained. A more complete article will, however, be published in our annual report for the year.

FIRST APPEARANCE—SPREAD—INVESTIGATION.

Our attention was first called to this pest in September, 1887, when Mr. I. W. Nicholson, of Camden, N. J., wrote us under date of September 22, as follows:

Herewith I send some specimens of flies which appear to have made their first appearance about the middle of August. They are very annoying to cattle, but rarely settle upon the horses or mules. They gather in patches or clusters particularly upon the legs, and are very active. I should like to know if they are common in other parts of the United States. They appear to be very numerous in all the counties near Philadelphia, yet I have seen no person who has observed them before this season.

Later letters the same season from Mr. Nicholson mentioned the common habit of clustering upon the horns, and the fact that after a severe frost in the middle of October the fly disappeared.

May 15, 1888, the same gentleman wrote us that the flies had promptly made their appearance May 10, or a little before, in great numbers. A few days later we heard of the same insect in Harford County, Md.,

through Mr. George R. Stephenson, who reported its occurrence in that locality the previous summer.

By the summer of 1889 the pest had extended in numbers much farther to the southward, and the Department was early informed of its occurrence in Harford and Howard Counties, Md., and Prince William, Fauquier, Stafford, Culpeper, Louisa, Augusta, Buckingham, and Bedford Counties, Va. The alarm became so great that we were anxious to learn all that was possible about the species, and arranged to have it investigated. Considerable time has therefore been devoted to the study of the habits and life history of the insect. This was done mainly by Mr. Howard, who made a number of short trips to The Plains, Warrenton, and Calverton during June and July. Later in the season Mr. Marlatt assisted in the work, which had been greatly facilitated by Mr. G. M. Bastable, Mr. David Whittaker, Mr. M. M. Green, and Mr. William Johnson, and particularly by Col. Robert Beverly. To the courtesies of these gentlemen we would acknowledge our indebtedness. August 20 Mr. Howard found the flies practically in Washington—in Georgetown—and the next day Mr. Marlatt found them in Rosslyn, at the Virginia end of the Aqueduct Bridge, so that further trips for material were not necessary.

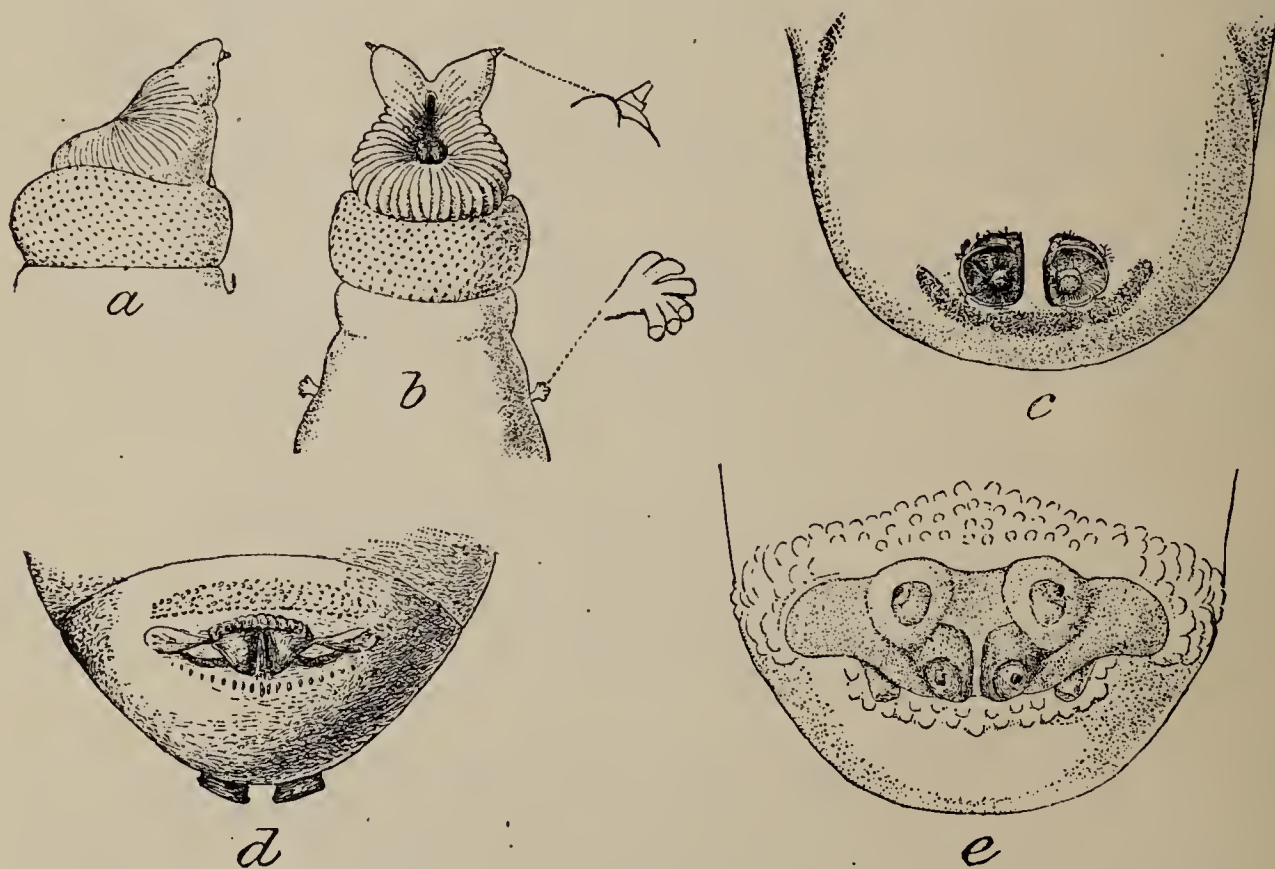


FIG. 12.—*HÆMATOBIA SERRATA*: *a*, side view of head of larva; *b*, ventral view of head of larva, showing antennæ and thoracic stigmata; *c*, dorsal view of anal end of larva, showing anal stigmata; *d*, anal plate of puparium; *e*, ventral view of anal end of larva, showing anal plate—still more enlarged. (Original.)

The result of the summer's observations by these two gentlemen is that the life history of the insect has been accurately made out from the egg to the fly through several consecutive generations, and that substances can be recommended which, from their experience, will keep the flies away for from five to six days, while from the life history

a suggestion as to preventives is made, which, under certain circumstances, will prove undoubtedly of great benefit.

IS IT A NATIVE OR AN IMPORTED PEST?

Since this insect was first brought to our notice we have felt that it was an imported pest. Its first appearance in the neighborhood of Philadelphia and its gradual spread southward have favored this idea. Dr. Williston, to whom we sent specimens for name, wrote us that he thought it an introduced species, and very close to *Hæmatobia serrata* of Robineau-Desvoidy, differing only in color of legs and antennæ. He has since, however, described it as a new species (see *Entomologica Americana*, Vol. V, No. 9, September, 1889, pp. 180-181), under the name *Hæmatobia cornicola*, giving *H. serrata* as a questionable synonym. His published remarks on this point are:

I can not resist the belief that the species is an introduced one, and suspect that it may be identical with *H. serrata* R.-Desv., occurring in France. Aside, however, from the discrepancies that his description shows in the color of the legs, an identification of this author's species is usually, at least, only a guess. Macquart's very brief description is better; but the palpi are distinctly enlarged, and he says they are not. Nothing but a comparison of the specimens will settle the question.

Meantime Dr. Lintner had sent specimens to Baron Osten-Sacken at Berlin, who determined them, as Dr. Lintner informs us in a letter dated September 16, as the European *serrata*, placing it in the closely allied genus or subgenus *Lyperosia* of Rondani. We are quite inclined to accept Baron Osten-Sacken's dictum in this matter and so also we feel assured will Dr. Williston, and we hence conclude that our species is the European *serrata*, whether it be ultimately placed in *Hæmatobia* or *Lyperosia* both of which genera were split off from *Stomoxys* and are considered by Schiner as subgenera of this last. At present we shall follow Dr. Williston in placing it in *Hæmatobia*.

We know little of the European geographical distribution of *H. serrata*. Robineau-Desvoidy described it from France and Schiner gives its location as south France, while Macquart gives it as inhabiting the south of France, and records it specifically from Bordeaux. The fact that in this country it has spread with much greater rapidity towards the south than towards the north would seem to indicate that it is a south European species.

The habits of *Hæmatobia* in Europe are given by Railliet* as follows:

The *Hæmatobias* are very small flies which live in the fields and seldom penetrate into the stables. As their name indicates, they are at least as blood-thirsty as *Stomoxys*. They attack the animals in the pastures, particularly cattle, and they often collect in great numbers upon a single individual, with their wings expanded, working in through the hairs to pierce the skin. *H. stimulans* Meig. and *H. ferox* R.-D. are the principal species of our region.—[France.]

The exact time and place of the introduction, it is impossible to ascertain. Upon its first importation in small numbers it was probably for

* *Éléments de Zoologie Médicale et Agricole.*

some time unnoticed, and its first noticeable appearance may not have been at the point of importation.

All imported cattle from Europe pass through the quarantine stations of this Department at either Littleton, Mass., Garfield, N. J., or Patapsco, Md., and an examination of the records develops one or two points of interest. Since 1884 only ten head of cattle have been imported into the country direct from France. All of these have passed through the New Jersey station, but their ultimate destinations have in no cases been within the regions now infested with the fly. The other importations have been from points like Antwerp, London, Amsterdam, Hamburg, Glasgow, Liverpool, Southampton, Hull, Rotterdam, and Bristol. The year 1886, immediately preceding the appearance of the fly, was marked by quite an extensive importation of Holsteins from Amsterdam and Rotterdam and London, through the Garfield station, mainly for parties in New York City. Over three hundred were imported, and an interesting point to investigate will, therefore, be the occurrence or non-occurrence of this fly in Holland.

POPULAR NAMES AND POPULAR ERRORS.

The popular name which is here adopted—the “Horn Fly”—has the sanction of popular use. It is sufficiently distinctive and we therefore recommend its adoption. The name of “Texas Fly” and “Buffalo Fly” and “Buffalo Gnat” are also in use in some sections and indicate an impression that the insect came from the West. Dr. Lintner uses the term “Cow-horn Fly.” Objections may be urged to all of these.

The most prominent of the popular errors is the belief that the fly damages the horn, eats into its substance, causes it to rot, and even lays eggs in it which hatch into maggots and may penetrate to the brain. There is no foundation for these beliefs. As we shall show later, the flies congregate on the bases of the horns only to rest where they are not liable to be disturbed. While they are there they are always found in the characteristic resting position, as shown in Fig. 14, and described later. Where they have been clustering thickly on the horns, the latter become “fly-specked” and appear at a little distance as though they might be damaged, and it is doubtless this fact which has given rise to the erroneous opinions cited.

LIFE HISTORY.

THE EGG.—*Place, Method, and Time of Oviposition.*—Mr. Howard’s first impression upon entering the field, that the eggs would be found to be laid in freshly dropped dung, proved to be correct. He brought to Washington with him from Calverton dung dropped on the night of July 28 and exposed in the field during the 29th, and from this dung the first adult flies, five in number, issued August 7, only ten days from the laying of the eggs. This settled the point of place of oviposition and breeding. It seemed probable that this was the only substance in which the species breeds, as indeed it is the only likely substance which

exists in sufficient quantity through the pastures to harbor the multitudes of flies which are constantly issuing through the summer. However, many living females were captured and placed in breeding cages with horse-dung and decaying animal and vegetable material of different kinds, each isolated, and it resulted that a few oviposited in the horse-dung and four flies were reared from this substance. There is no evidence, however, that in a state of nature the flies will lay their eggs in anything but cow-dung.

The time and manner of oviposition were puzzling at first. After hours of close watching of fresh dung in pastures close to grazing cattle not a single *Hæmatobia* was seen to visit the dung, much less to lay an egg. This close observation was made at all times of the day from dawn till dusk without result, while breeding-cage experiments were all the time proving that nearly all fresh droppings contained many eggs. With some hesitation, therefore, the inference was made that the eggs were presumably laid at night, as stated in the note upon p. 60 of the August number of *INSECT LIFE*.

The question was, however, considered by no means settled, and on the discovery of the fly at Rosslyn Mr. Marlatt was directed to make especial observations upon this point. The first result was that careful examination of dung dropped in the early morning (prior to 7 a. m.) showed very few eggs, not more than eight or ten to a single dropping, while that dropped between 4 p. m. and later in the night contained still fewer. On a dung dropped between 10 and 11.30 a. m. in the hot sunshine, however, examination, a few minutes after, showed a large number of eggs—estimated at three hundred and fifty. Other very fresh droppings were examined and the eggs were found to range from none at all to over three hundred. One animal was then fortunately observed, from close quarters, in the act of passing her dung. As the operation commenced, forty or fifty of the flies moved from the flank to the back of the thigh near the "milk mirror," and at the close of the operation they were seen to dart instantly to the dung and to move quickly over its surface, stopping but an instant to deposit an egg. The abdomen and ovipositor were fully extended and the wings were held in a resting position. Most of them had left the dung at the expiration of thirty seconds, while a few still remained at the expiration of a minute. Every individual had returned to the cow, however, in little more than a minute. This explains the previous non-success in observing the act of oviposition, for the Virginia cattle on the large stock-farms are comparatively wild, and although the dung was examined as speedily as possible after dropping, the flies had already left.

The results, therefore, indicate that the eggs are deposited during daylight, chiefly during the warmer time of the day, between 9 and 4, and mainly between 9 in the morning and noon. They are laid singly, and never in clusters, and usually on their sides on the surface of the wet dung; seldom inserted in cracks.

Description —Length, 1.25^{mm} to 1.37^{mm}; width, 0.34^{mm} to 0.41^{mm}. Shape, irregular oval, nearly straight along one side, convex along the other. General color, light reddish brown, lighter after hatching. General surface covered with a hexagonal, epithelial-like sculpture, each cell from .027^{mm} to .033^{mm} in length by about half the width. In the unhatched egg, even in those just deposited, a long, rather narrow, ribbon-like strip is noticed along the entire length of the flattened side, rather spatuloid in shape. In hatching this strip splits off, remaining attached at one end, and the larva emerges from the resulting slit.

LARVA.—After the eggs hatch the larvæ descend into the dung, remaining, however, rather near the surface.

Newly-hatched Larva.—Length, 2.45^{mm}, and greatest width, 0.48^{mm}. Color, pure white. Joints of segments rather plainly marked, venter with slightly elevated ridges at ends of abdominal segments, the ridges with delicate sparse rugosities. Resembles in main full-grown larva.

Full-grown Larva.—Length, 7^{mm}; greatest width, 2 to 2.5^{mm}. Color, dirty white. Antennæ 3-jointed, last joint pointed. Head with a lamellar or ridged structure shown in figure; divided by cleft at tip; skin behind lamellar structure coarsely granulated, while that of thoracic and abdominal joints is nearly smooth. Thoracic stigmata pedunculate with six pedunculate orifices. Ridges on venter of abdominal joints not strong, fainter than in young larva. Anal stigmata large, slightly protruding, very dark brown, nearly round, flattened on proximal borders, slightly longer than broad, 0.14^{mm} in length, with one central round opening, and a series of very delicate marginal tufts of cilia, four tufts for each spiracle, each issuing from a cleft, but none on the proximal edge. Anal segment below with a dark yellow chitinous plate showing six irregular paired tubercles; the surface of the skin surrounding the plate rather coarsely granulated.

PUPARIUM.—When ready to transform the larvæ evidently descend from the dung into the ground below from a half to three-quarters of an inch. Actual observations were made on larvæ in dung in breeding-cages where the soil was fine sand, affording ready entrance to the larvæ. Where the dung has been dropped upon hard ground the probabilities are that they will not enter so deeply, and may indeed transform upon the surface of the ground at the bottom of the dung.

Description.—The puparium is from 4^{mm} to 4.5^{mm} in length, by 2^{mm} to 2.5^{mm} in width, regularly ellipsoidal, the head rather more pointed; dark brown in color. The segments are plainly separated. The anal stigmata are darker in color than the rest of the skin; are slightly protruded and preserve the same shape as in the larva. The central opening is still visible, as are the slight indentations of the border. The ventral plate, noticed at the base of the anal segment of the larva is still noticeable as a series of tubercular elevations.

DURATION OF THE PREPARATORY STAGES AND CONSEQUENT NUMBER OF ANNUAL GENERATIONS.—The first flies reared at the Department issued August 7 from eggs deposited July 28. These were five or six in number. August 8 four more issued from the same lot. August 12 six flies issued, reared from eggs laid July 31; August 13 two more, and August 14 two more from the same lot. Delayed specimens issued from this lot August 20 and 23. August 26 seven flies were reared from two or three days' old dung, collected August 17. These observations show the bulk of the flies during late July and August to issue from ten to fifteen days from the laying of the eggs. In all cases the eggs hatched

in less than twenty-four hours. Experiments a little later gave the following periods:

Aug. 21. Eggs deposited in confinement placed at 7 p. m. on cow dung free from eggs of other flies.

23. Larvæ one-fourth grown.

25. Larvæ one-half inch long.

27. Larvæ leaving manure and entering sand to pupate.

Sept. 5. Three flies issued.

Aug. 23. Eggs placed with isolated dung at 1.30 p. m.

24. (9 a. m.) Eggs have hatched.

25. Larvæ one-fourth inch long.

29. Apparently full grown.

30. Puparia found.

Sept. 5. Two flies issued.

6. Four flies issued.

1. Eggs deposited 10.25 a. m.

2. Eggs were hatched when examined at 9 a. m.

5. Larvæ half grown.

7. Larvæ entering sand.

8. Five puparia taken from sand.

9. All in puparia.

15. Three adults.

16. Twenty adults.

17. Twenty-six adults.

} All found at 9 a. m.

17. Twenty adults, issued between 12 and 4 p. m.

From these records it will be seen that from ten to seventeen days, say two weeks, is about the average time from the laying of the egg to the appearance of the flies, and with four active breeding months, from May 15 to September 15, there will be eight generations. The flies will undoubtedly breed later than September 15, but we may allow this time to make up for the time occupied in the development of the eggs in the abdomen of the female. With seven or eight annual generations the numbers of the flies are not surprising.

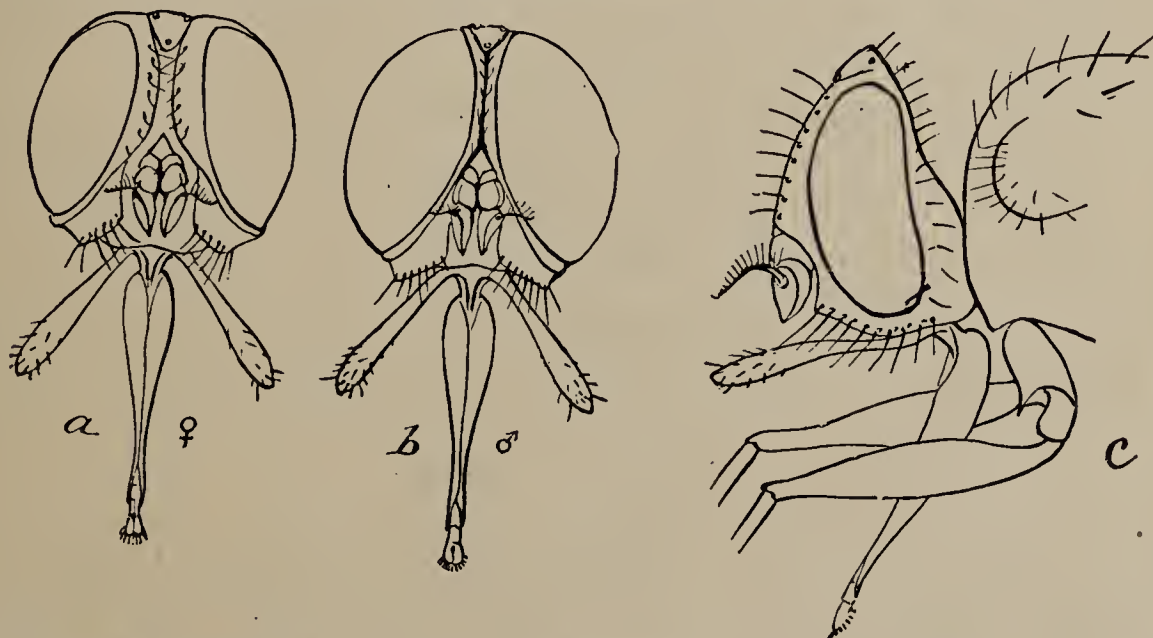


FIG. 13.—*HÆMATOBIA SERRATA*: *a*, head of female, front view; *b*, head of male, front view; *c*, head from side—all enlarged. (Original.)

THE ADULT—*Its Habits.*—The flies were observed in the greatest abundance during July. They make their first noticeable appearance

in Virginia early in May, and, from hearsay evidence, remain until "late in the fall" or until "right cold weather." At the date of the present writing, September 28, they are still as abundant as ever around Washington. The characteristic habit of clustering about the base of the horn seems to exist only when the flies are quite abundant. When they average only a hundred or so to a single animal, comparatively few will be found on the horns. Moreover, as a general thing the horn-cluster-



FIG. 14.—*HÆMATOBIA SERRATA*: Adult in resting position—enlarged. (Original.)

ing habit seems to be more predominant earlier in the season than later, although the flies may seem to be nearly as numerous. The clustering upon the horns, although it has excited considerable alarm, is not productive of the slightest harm to the animal. Careful study of the insects in the field show that they assume two characteristic positions, one while feeding and the other while resting. It is the resting position in which they are always found when upon the horns. In this position the wings are held nearly flat down the back, overlapping

at base and diverging only moderately at tip (see Fig. 14). The beak is held in a nearly horizontal position and the legs are not widely spread. In the active sucking position, however, the wings are slightly elevated and are held out from the body, not at right angles, but approaching it, approximately an angle of 60 degrees from the abdomen. The legs are spread out widely, and the beak, inserted beneath the skin of the animal, is held in nearly a perpendicular position, approaching that in Fig. 13c. The fly, before inserting its beak, has worked its way through the hairs close to the skin. While feeding, however, the hairs which can be seen over its body do not seem to interfere with its speedy flight when alarmed, for at a fling of the tail or an impatient turn of the head the flies rise instantly in a cloud for a foot or two, returning again as quickly and resuming their former positions.

The horns are not the only resting places, for with the horns black for 2 inches above their base we have seen the flies towards nightfall settle in vast numbers upon the back between the head and fore shoulders, where they can be reached by neither tail nor head. When feeding they are found over the back and flanks and on the legs. During a rain-storm they flock beneath the belly. When the animal is

lying down a favorite place of attack seems to be under the thigh and back belly, around the bag. With certain animals the dewlap seems to be badly attacked while with others this portion of the body is about exempt. Certain cattle again will be covered with flies and will lose condition rapidly, while others are but slightly troubled.

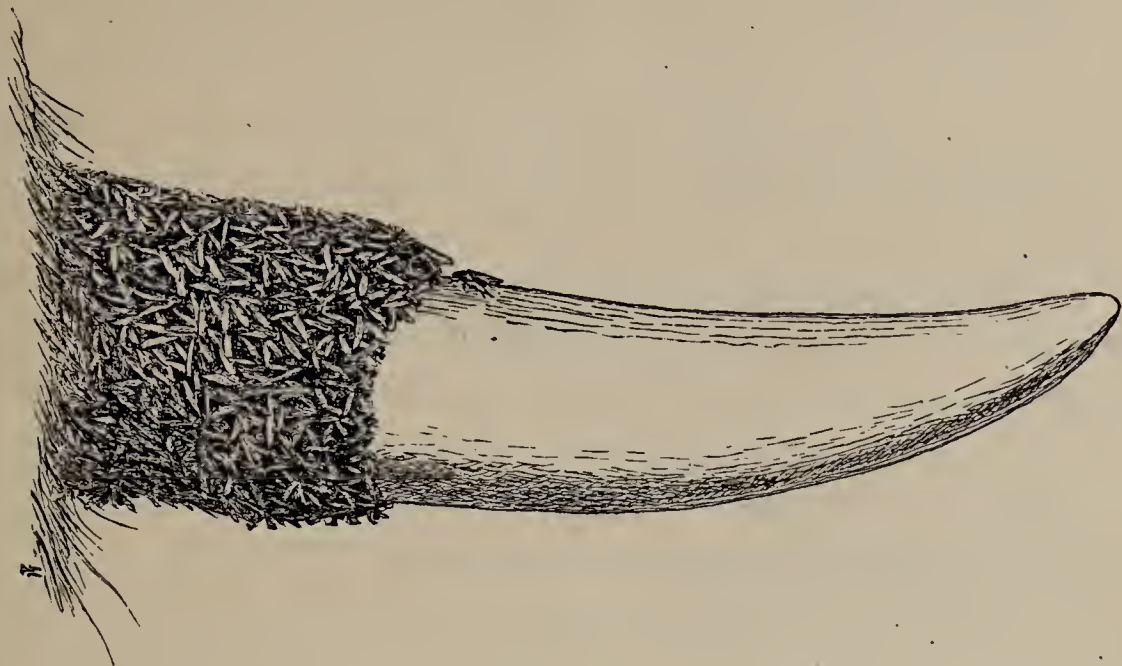


FIG. 15.—Cow-horn showing band of resting flies—reduced. (Original.)

On the horns the flies settle thickly near the base, often forming a complete band for a distance of 2 inches or more. (See Fig. 15.) They seem to prefer the concave side to the convex side of the curve of the horn, probably for the reason that the cow can not scrape them off so readily, and one cow was noticed in which they reached nearly to the tip of the horn on the concave side of the curve only.

Description.—For a description of the adult we may adopt that sent us by Dr. Williston, which was drawn up from Virginia specimens which we had sent to him, and which is substantially identical with that published by him recently in *Entomologica Americana* (*loc. cit.*).

Male.—Length 3.5 to 4^{mm}. Sides of the front gently concave, its least width about equal to one-fourth of the distance from the foremost ocellus to the base of the antennæ; in the middle a narrow, dark brown stripe; a single row of slender bristles on each side. Antennæ brownish red; second joint slightly tumid; third joint a little longer than broad, with its inferior angle rectangular; arista swollen at the base (which is black), the pectination long. The narrow sides of the front, and the still narrower facial and genal orbits silvery gray, with a slightly yellowish cast; facial foviæ and cheeks blackish, the latter clothed with yellowish hair. Palpi black, the inner surface and immediate base more yellowish; gently spatulate in shape, nearly as long as the proboscis, and extending two-thirds of their length beyond the oral margin. Mesonotum sub-shining black in ground-color, but mostly concealed beneath a brownish dust, which, on the pleuræ, is more grayish. Abdomen with similar dust; in the middle with a more brownish sub-interrupted stripe, and narrow darker posterior margins to the segment. Femora black, or very deep brown, first two pairs of tibiæ and tarsi brownish yellow or luteous, the hind tibiæ and tarsi blackish brown; hind tibiæ on the posterior surface with a noticeable, erect, subapical bristle; hind tarsi about as long as their tibiæ, the first three joints widened from their base to tip, so

as to form a distinct serration on their inner, acute angles, each of which terminates in a long hair. Wings with a light blackish tinge (due to microscopic pubescence), the immediate base yellowish, the first posterior cell rather symmetrically narrowed to terminate broadly at the extreme tip of the wing.

Female.—Front straight on the sides, its width about equal to one-half of the distance from the foremost ocellus to the base of the antennæ; the median deep brown stripe about as wide as the pruinose sides. Palpi yellow, with the margins and tip blackish. Legs more yellowish; hind tarsi regular; pulvilli and claws small.

AMOUNT OF DAMAGE.

The amount of damage done by the fly has been exaggerated by some and underestimated by others. We have heard many rumors of the death of animals from its attacks, but have been unable to substantiate a single case. We believe that the flies alone will never cause the death of an animal. They reduce the condition of stock to a considerable extent, and in the case of milch cows the yield of milk is reduced from one-fourth to one-half. It is our opinion that their bites seldom even produce sores by themselves, although we have seen a number of cases where large sores had been made by the cattle rubbing themselves against trees and fences in an endeavor to allay the irritation caused by the bites; or, in spots where they could not rub, by licking constantly with the tongue, as about the bag and on the inside of the hind thighs. A sore once started in this way will increase with the continued irritation by the flies and will be difficult to heal. Those who underestimate the damage believe that the flies do not suck blood, but such persons have doubtless watched the flies only upon the horns or elsewhere in their resting position when the beak is not inserted, or have caught them and crushed them when their bodies contained little blood. In reality the flies suck a considerable amount of blood, however, and it is their only nourishment; if captured and crushed at the right time the most skeptical individual will be convinced.

REMEDIES.

Preventive Applications.—Almost any greasy substance will keep the flies away for several days. A number of experiments were tried in the field, with the result that train-oil alone, and train-oil with a little sulphur or carbolic acid added, will keep the flies away for from five to six days, while with a small proportion of carbolic acid it will have a healing effect upon sores which may have formed. Train-oil should not cost more than from 50 to 75 cents per gallon, and a gallon will anoint a number of animals. Common axle grease, costing 10 cents per box, will answer nearly as well, and this substance has been extensively and successfully used by Mr. William Johnson, a large stock dealer at Warrenton, Va. Tallow has also been used to good advantage. The practice of smearing the horns with pine or coal-tar simply repels them from these parts. Train-oil or fish-oil seems to be more lasting in its effects than any other of the substances used.

Applications to destroy the Fly.—A great deal has been said during the summer concerning the merits of a proprietary substance, consisting mainly of tobacco dust and creosote, known as "X. O. Dust," and manufactured by a Baltimore firm, as an application to cattle, and it has received an indorsement from Prof. J. B. Smith, Entomologist to the New Jersey Experiment Station. We are convinced that this substance has considerable merit as an insecticide, and know from experience that it will kill many of the flies when it touches them, although they die slowly, and a few may recover. The substance costs 25 cents per pound, and is not lasting in its effects. Where it is dusted through the hair the flies on alighting will not remain long enough to bite, but two days later, according to our experience, they are again present in as great numbers as before. A spray of kerosene emulsion directed upon a cow would kill the flies quite as surely, and would be cheaper, but we do not advise an attempt to reduce the numbers of the pest by actually killing the flies.

How to destroy the early Stages.—Throwing a spadeful of lime upon a cow dung will destroy the larvæ which are living in it, and as in almost every pasture there are some one or two spots where the cattle preferably congregate during the heat of the day, the dung which contains most of the larvæ will consequently be more or less together and easy to treat at once. If the evil should increase, therefore, it will well pay a stock raiser to start a load of lime through his field occasionally, particularly in May or June, as every larva killed then represents the death of very many flies during August. We feel certain that this course will be found in many cases practical and of great avail and will often be an advantage to the pasture besides.

OTHER FLIES REARED FROM COW DUNG.

Our observations on the life-history of the Horn-fly have been greatly hindered and rendered difficult by the fact that fresh cow dung is the nidus for a number of species of Diptera, some of about the same size and general appearance. We have in fact, chiefly this summer, reared no less than twenty distinct species of flies from horse and cow dung, mainly from the latter, and six species of parasitic insects. We shall give these some consideration in our final article in the annual report, but can not elaborate here. The plan finally adopted to secure the isolation of the *Hæmatobias* was to remove the eggs from the surface of the dung and place them with dung which was absolutely fresh and collected practically as it fell from the cow. Even in this way very great care was necessary to prevent the occurrence of other species.



